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Linking intermediate depth seismicity to plate-bending related faulting

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The amount of bending-related faulting near the trench of a subduction zone partly controls the amount of plate hydration, because the large damage zones create pathways for the seawater to infiltrate the subducting lithosphere. It has been proposed that this water is released between 70 and 350 km depth in dehydration reactions that cause so-called intermediate depth earthquakes. However, a definite relationship between incoming plate faulting and intermediate depth seismicity has not been established so far. Here, we look into this problem with a range of interdisciplinary tools.

We present a dataset of bending subducting plate faulting parameters such as earthquake moment tensor solutions, focal depths, fault spacing, offset measurements, plate age, and convergence rates for 11 subduction zones. We also present an intermediate depth seismicity dataset for those 11 subduction zones, which includes parameters such as the maximum seismic moment, seismicity rate, and the thickness of double seismic zones. We correlate these two datasets to find relationships between bending related outer rise faulting and intermediate depth seismicity.

We find that the number of intermediate depth earthquakes per km has a more robust linear correlation with incoming plate fault throw than with plate age, convergence rate, or thermal parameter. This may indicate that the structural heterogeneity of old outer rise fault planes influences the productivity of intermediate depth earthquakes. To assess whether or not a purely structural explanation for intermediate depth earthquakes is plausible, we also compare the estimated seismic moment release for plate related bending to the seismic moment release of the intermediate depth earthquakes.

To further assess the process of intermediate depth earthquake activation by dehydration processes of the outer rise faults, we develop a geodynamic model in which we first create bending related faulting by extending a slab of oceanic crust. To mimic the change in stress regime at intermediate depth, we convert the boundary conditions to compression to see how the faults will develop. By varying the time at which we convert the boundary conditions (which relates to the subduction velocity), we get an insight into how intermediate depth earthquakes can occur on the previously existing outer rise faults.